What is claimed is:

1. A digital single tuner set top decoder (hereafter STB), comprising:

one or more data paths which can take the form of one or more buses for coupling to a control circuit and hereafter referred to as a bus;

a frequency nimble QAM channel tuner having a control input coupled to said bus, and having an input for coupling to coaxial cable of a cable TV system;

a quadrature amplitude (QAM) demodulator means coupled to receive signals output by said tuner for recovering data of a transport stream or multiplex therefrom;

a transport stream demultiplexer means coupled to receive filter instructions from said bus for extracting and outputting packets having selected PIDs from said transport stream or multiplex including at packets having a DOCSIS PID, and routing said extracted packets to appropriate circuits to process each type of packet;

a conditional access means for receiving a decrypted session key and encrypted packets sent to said conditional access means by said transport stream multiplexer and for decrypting some of said encrypted packets using said session key to recover a working key and using said working key to decrypt encrypted packets of said requested program;

decompression means coupled to receive decrypted video packets from said conditional access means and audio and other packets that comprise said requested program, for decompressing and decoding said packets so as to output YUV or RGB information and properly synchronized audio information;

an encoder means for receiving said YUV or RGB information and generating a video signal therefrom;

a remodulation circuit for receiving said video signal from said encoder and for receiving an audio signal, and for modulating said video and audio signals onto a radio frequency carrier having a predetermined frequency;

a control circuit for receiving user commands and controlling said set top box by communicating with selected circuits in said set top box via said bus or other data paths;

a memory coupled to said control circuit for storing packets routed thereto by said transport stream demultiplexer;

key store means for storing a private user key of said set top decoder in nonvolatile memory and decrypting a session key in an EMM message using said private user key; and

a DOCSIS upstream transmitter coupled to said control circuit by said bus.

2. [conditional access circuit and key store means are removable smart card] The apparatus of claim 1 wherein said key store means and said conditional access means are both embodied in a removable card which contains a secure microprocessor to perform the function of at least said conditional access means, and wherein said decompression means and said encoder means are removable as one or more modules and can be replaced individually or as a unit by one or more modules which contain decompression circuitry for different compression standards and encoder circuitry to encode output from said decompression circuitry into a selected one of a plurality of different television signal standard formats.

3. [two way conditional access] The apparatus of claim 1 wherein control circuit includes means to receive requests for encrypted programs and to send an upstream message requesting transmission of a session key needed to decrypt a working key transmitted with said requested program and to receive a downstream message containing the encrypted session key and decrypt said session key with a private user key and then use the decrypted session key to decrypt a working key transmitted with the encrypted program data and use the decrypted working key to decrypt the encrypted program data.

4. [EMM and ECM decrypted in smart card, CA decrypts video] The apparatus of claim 1 wherein said key store means contains a nonvolatile memory with stores said private user key and contains a secure microprocessor which is programmed to use said private user key to decrypt a session key in EMM message bearing MPEG packet routed to said secure microprocessor by said transport stream demultiplexer, and programmed to use said decrypted session key to decrypt ECM messages in MPEG packets extracted by said transport stream demultiplexer and sent to said secure microprocessor so as to recover a working key, and programmed to send said working key to said conditional access means, and wherein said removable card is connected to the rest of the circuitry of said set top

decoder by an edge connector or a series of conductive contact pads with mate with conductors which touch said pads when said card is seated in said set top decoder.

5. [upstream message sent even for request for broadcast and request immediate transmission of I frame and narrowcasting] The apparatus of claim 1 wherein said control circuit is a microprocessor programmed to receive requests for a broadcast channel or a video-on-demand program or a pay-per-view event, and generate and send upstream requests via said DOCSIS upstream transmitter to download any application programs needed and to download any decryption keys needed to decrypt said requested program and to send an I-frame immediately via said DOCSIS PID or via a "native" transmission normally used to transmit I-frames, and wherein said upstream messages include an indication of the QAM channel(s) on which said set top decoder is tuned to receive downstream M&C messages such that said headend can narrowcast M&C messages to only the cable modems that need them thereby minimizing the number of QAM channels on which downstream messages must be sent.

6. [application programs sent down on DOCSIS PID, extracted and installed] The apparatus of claim 5 wherein said microprocessor is programmed to receive MPEG packets having the DOCSIS PID and extract management and control messages and data therefrom including application programs and programmed to install on said microprocessor any said application program needed to do any necessary processing in said set top decoder for functions for which the software is not resident and execute said program.

7. [functions of control circuit for both VOD and b'cast] The apparatus of claim 1 wherein said control circuit performs the following functions:

receive user commands including commands to view digital video broadcast channel lineups or video-on-demand menus;

receive and display channel lineup data and/or video-on-demand menus, and navigate on on-screen menus, channel lineup tables etc. in response to user commands, and receive user selection commands such as requests to view particular video broadcast channels or view particular video-on-demand selections;

send management and control data on a DOCSIS upstream including requests for video on demand programs, reports of channel selections for video broadcasts,

requests for conditional access keys for selected programs, requests to download software applications needed to provide various services, and indicating to which QAM channel the STB is tuned;

receive downstream messages on the DOCSIS PID in an MPEG transport stream and recover the data therein;

receive requested software applications transmitted in MPEG packets having the DOCSIS PID and recover and install them;

search the channel lineup table using data regarding a user selection of a broadcast channel to find a corresponding mapping entry for the selected video broadcast and gather data regarding which QAM channel the requested digital video broadcast will be on and what will be the PIDs of its video, audio, PCR timing, supplemental data, ECM message and, in some embodiments, the EMM message carrying the session key for the selected channel or program;

receive and recover the data from downstream messages on the DOCSIS PID in response to upstream VOD requests, said downstream messages indicating the QAM channel on which said VOD request will be sent, the transport stream on which said VOD request will be sent and information from which the PIDS of the component parts of said requested VOD program can be obtained directly or indirectly;

perform all necessary functions to send tuning commands and any other data needed to cause said tuner to tune and receive the appropriate QAM channel containing the requested program;

send appropriate configuration data to said QAM demodulator so that it can demodulate, deinterleave and error correct the received data of an MPEG multiplex or transport stream sent on a QAM channel;

determine the PIDs of the component parts of the requested video program including at least the video, audio, and PCR timing, and the ECM message data or attribute if said ECM message is sent as part of the video program;

receive EMM messages containing encrypted session keys and addressed or encrypted so that only said STB which sent said upstream request for a video program can decrypt them using a private user key of said STB, and either decrypt said session key using said private user key or send the EMM messages to key store means for decryption so as to obtain a decrypted session key;

send the decrypted session key to appropriate circuitry for decryption of a working key in said ECM message or recover said working key in said control circuit using said decrypted session key and send said working key to said conditional access means; and

generate and send to said transport stream demultiplexer appropriate filter commands to cause MPEG packets having PID 0 and the DOCSIS PID to be selected from said MPEG multiplex and sent to said control circuit and to cause MPEG packets having the video PID to be extracted and sent to said conditional access means for decryption and to cause MPEG packets having the audio PID, PCR PID and supplemental data PID to be extracted and sent to the appropriate circuits for processing to decode said audio data and synchronize it with decoded video data, and to extract MPEG packets having a PID indicating they carry an EMM message and sent them to the appropriate circuit for decryption of the session key.

8. The apparatus of claim 7 wherein said control circuit is a microprocessor programmed to find the PIDs of the component parts of the requested VOD program by performing the following functions:

construct a PAT table from said MPEG packets having PID 0 which are extracted by said transport stream demultiplexer and stored in said memory for processing by said control circuit when a video-on-demand program has been selected;

use the PAT table to determine the transport streams that are in any MPEG multiplex output from said quadrature amplitude demodulator and the programs that are in each transport stream;

process the PAT table to determine the PID of packets encoding a PMT table for particular requested video-on-demand program carried on a particular MPEG transport stream;

send filter commands to the transport stream demultiplexer telling it to filter out MPEG packets having the PID of said PMT table and use said PMT table to determine the PIDs of the component parts of the requested VOD program.

9. The apparatus of claim 8 wherein said microprocessor is programmed to perform the step of using the PCT table to determine the PIDS of the component parts of the requested VOD program by performing the following steps:

receive MPEG packets having the PID of said PMT table from said transport stream demultiplexer and reconstruct said PMT table;

determine from data in said PMT table which PIDs MPEG packets encoding various parts of said requested VOD program will have;

generate and send to said transport stream demultiplexer filter commands suitable to cause said transport stream demultiplexer to filter out at least MPEG packets bearing video, audio, ECM and PCR timing data of said requested video-on-demand program and send said extracted MPEG packets to appropriate circuitry in said STB for decoding.

10. The apparatus of claim 1 wherein said control circuit is a microprocessor programmed to receive MPEG packets having the DOCSIS PID which contain a channel lineup table which contains all information needed to determine all necessary information to tune to a digital video broadcast table including the PIDS of at least channels to which said set top decoder has a subscription, and is further programmed to reconstruct said channel lineup table and seach said channel lineup table for the channel for which a request to view has been received from a user and determine the PIDs of video, audio, PCR and other components of said requested channel and use said PID information to program said transport stream demultiplexer and use other information gleaned from said channel lineup table to send appropriate commands to said tuner and said quadrature amplitude demodulator to properly receive said requested channel.

11. The apparatus of claim 1 wherein said control circuit is a microprocessor programmed to receive a request for a VOD program(s) and generate and send via said DOCSIS upstream transmitter a request to download only the conditional access key(s) needed to decrypt the requested VOD program(s).

12. [requests immediate download of an I-frame] The apparatus of claim 1 wherein said control circuit is a microprocessor programmed to receive a request for a VOD program(s) and generate and send via said DOCSIS upstream transmitter a request to

download only the conditional access key(s) needed to decrypt the requested VOD program(s) and download of the MPEG data of the program and any application program software needed to service the request, and wherein said microprocessor is further programmed to request immediate download of an MPEG I-frame for the requested program such that decoding of the requested program data in the Decompression means can begin immediately upon receipt of the I-frame and the rest of the MPEG data of the program does not have to wait for the I-frame for the program to come in the natural order of the MPEG transport stream.

13. The apparatus of claim 1 wherein said tuner is structured such that it can be tuned to a frequency of a downstream channel on which an MPEG multiplex is modulated and filter out radio frequency signals outside said downstream channel, and reduce the frequency of the received signal to an intermediate frequency and digitize said intermediate frequency signal.

14. The apparatus of claim 1 wherein said control circuit is a microprocessor programmed to receive a request to tune a digital broadcast channel or a video-on-demand program and respond by sending an upstream request for immediate downstream transmission of an MPEG I-Frame for said requested broadcast channel or video-on-demand program.

15. The apparatus of claim 1 wherein said tuner contains narrowband excision circuitry to remove narrowband noise.

16. The apparatus of claim 1 wherein said control circuit includes a LOLA interface for detecting the digital broadcast channel a user wishes to view by receiving electromagnetic radiation from the local oscillator of a television set coupled to said STB.

17. The apparatus of claim 1 wherein said tuner comprises:

a gain control circuit controlled by commands received at said control input;

a broad bandpass filter coupled to receive signals output by said gain control circuit and filter out unwanted radio frequency signals outside a frequency band which includes said selected channel;

a mixer and local oscillator coupled to mix output signals from said broad bandpass filter down to an intermediate frequency;

a narrow passband filter controlled by said control circuit to have a passband bandwidth equal to the bandwidth of said selected channel;

an analog-to-digital converter for digitizing the filtered signal output from said narrow passband filter.

18. The apparatus of claim 1 wherein said control circuit is a microprocessor programmed to execute a resident operating system and navigation program and programmed to request download of any other application program needed to carry out any function requested by a user which cannot be performed by said navigation program.

19. The apparatus of claim 1 wherein said control circuit is a microprocessor programmed to receive requests for encrypted digital video broadcast channels or encrypted video-on-demand programs and send upstream requests on a DOCSIS channel requesting downstream transmission of an encrypted session key for only said requested broadcast channel or video-on-demand program.

20. The apparatus of claim 1 wherein said control means is a microprocessor, and wherein said transport stream demultiplexer is structured or programmed to select out MPEG packets having PID 0 encoding a PAT table and storing said packets in said memory, and wherein said microprocessor is programmed to:

construct said PAT table from said MPEG packets having PID 0 stored in said memory;

use said PAT table to determine the transport stream that are in any MPEG multiplex output from said quadrature amplitude demodulator;

process said PAT table to determine the PID of a packets encoding a PMT table for an MPEG transport stream containing programs or services which have been requested;

send filter commands to said transport stream demultiplexer means telling it to filter out MPEG packets having said PID of said PMT table and store them in said memory;

construct said PMT table from said packets with said PID of said PMT table which have been stored in said memory;

compare the video programs or services which has been requested by a user to data in said PMT table to determine the PIDs which MPEG packets encoding said requested programs or services will have;

generate and send to said transport stream demultiplexer filter commands suitable to cause said transport stream demultiplexer to filter out MPEG packets bearing data of said requested programs and/or services.

21. The apparatus of claim 1 wherein said conditional access means comprises means for decrypting requested programs and services using a DOCSIS key exchange protocol.

22. The apparatus of claim 1 wherein said control circuit is programmed to receive EMM messages as a data carousel on the DOCSIS PID and select only EMM messages having the address or ID of said STB in the DOCSIS frame and recover an encrypted session key from said EMM messages corresponding to a requested video program using a private user key for said STB.

23. The apparatus of claim 1 wherein said control circuit is programmed to receive EMM messages as a data carousel on the DOCSIS PID and select only EMM messages having the address or ID of said STB in the DOCSIS frame and recover an encrypted session key from said EMM messages corresponding to a requested video program and send said encrypted session key to said key store means for decryption using a private user key for said STB.

24. A set top decoder apparatus comprising:

a quadrature amplitude modulated channel radio frequency tuner having an input for coupled to a hybrid fiber coaxial cable system;

a quadrature amplitude modulated channel digital demodulator coupled to receive digital sample data output from said tuner and functioning to recover MPEG packets;

an transport stream demultiplexer coupled to receive packets output from said demodulator and functioning to extract packets having selected PIDs or other identifiers and route them to appropriate circuitry in said set top decoder for further processing;

a decoder coupled to receive extracted compressed data packets from said transport stream demultiplexer for generating synchronized video and audio data of a requested video program;

an encoder to receive said video and audio data output by said decoder and generate video and audio signals therefrom;

a microprocessor coupled at least to said transport stream demultiplexer and said tuner for controlling said set top decoder; and

means for receiving user commands and transferring data to said microprocessor.

25. The apparatus of claim 24 further comprising a DOCSIS compatible cable modem bidirectionally coupled to said microprocessor and having an input for coupling to said hybrid fiber coaxial cable system and having a bus and/or local area network port, for sending and receiving broadband digital data over DOCSIS upstream and downstream channel on said hybrid fiber coaxial cable system.

26. The apparatus of claim 24 wherein said means for receiving user commands is a LOLA interface.

27. The apparatus of claim 24 further comprising a remodulator coupled to receive said audio and video signals from said encoder and convert them to an RF carrier on channel 3 or channel 4 modulated with said audio and video signals.

28. The apparatus of claim 24 wherein said means for receiving user commands is a LOLA interface, and further comprising a remodulator coupled to receive said audio and video signals from said encoder and coupled to receive RF output frequency commands from said microprocessor, and functioning to modulate said audio and video signals received from said encoder onto an RF carrier having a frequency defined by a command from said

microprocessor such that said RF carrier can be used by a conventional TV to display a requested video program.

29. A set top decoder apparatus comprising:

a radio frequency tuner having an input for coupled to a hybrid fiber coaxial cable system;

a QAM channel digital demodulator coupled to receive digital sample data output from said tuner and functioning to recover packets;

an transport stream demultiplexer coupled to receive packets output from said demodulator and functioning to extract packets having selected PIDs or other identifiers and route them to appropriate circuitry in said set top decoder for further processing;

a decompression decoder coupled to receive extracted packets from said transport stream demultiplexer and decompress them so as to generate synchronized video and audio data of a requested program;

an encoder for converting said video and audio data to video and audio signals;

a DOCSIS compatible cable modem having an input for coupling to a hybrid fiber coaxial cable system and having a bus and/or local area network output for coupling to one or more computers or other devices which need to send and/or receive DOCSIS data on DOCSIS upstream and downstream channels;

a microprocessor coupled to said DOCSIS compatible cable modem and coupled at least to said transport stream demultiplexer and said tuner, for controlling said set top decoder to receive requested video broadcasts and/or video-on-demand or pay-per-view programs, and programmed to receive management and control data from a headend via packets transmitted as part of said transport stream containing one or more video programs and for sending upstream management and control data via said DOCSIS compatible cable modem; and

means for receiving user commands specifying desired video programs to view and transferring data to said microprocessor.

30. An apparatus comprising:

a radio frequency receiver and frequency counter to receive and determine the frequency of radio frequency emissions of a local oscillator of a tuner of an analog TV which has been tuned to a requested analog TV channel;

a computer or inference engine coupled to receive the frequency detected by said radio frequency receiver and frequency counter and programmed or structured to use said frequency to look up the frequency of a corresponding analog TV channel and map that frequency to the frequency of a corresponding digital quadrature amplitude modulated radio frequency channel broadcast on a hybrid fiber coaxial cable CATV system by a headend and the PID or PIDs of a requested video program carried on a corresponding subchannel in an MPEG transport stream or MPEG multiplex carried on said quadrature amplitude modulated radio frequency channel;

means coupled to said computer or inference engine for receiving control signals generated by said computer or inference engine to tune to and receive said digital quadrature amplitude modulated radio frequency channel and recover the MPEG packets of said MPEG transport stream or MPEG multiplex and extract therefrom MPEG packets having said PID or PIDs of said requested video program and convert said MPEG packets to a video signal suitable for viewing on a TV;

a DOCSIS compatible cable modem coupled bidirectionally to said computer and inference engine and having an input for coupling to said hybrid fiber coaxial cable system and having a standard bus or local area network interface for coupling to personal computers, voice-over-IP telephony equipment or any other device that needs to send data to and/or received digital data from said headend.

31. The apparatus of claim 30 further comprising a remodulator for modulating said video signal onto an RF carrier having the frequency of said requested analog TV channel;

32. A set top decoder apparatus comprising:

a radio frequency tuner having an input for coupled to a hybrid fiber coaxial cable system;

a QAM channel digital demodulator coupled to receive digital sample data output from said tuner and functioning to recover packets;

an transport stream demultiplexer coupled to receive packets output from said demodulator and functioning to extract packets having selected identifiers and route them to appropriate circuitry in said set top decoder for further processing;

decompression means coupled to receive extracted packets from said transport stream demultiplexer for generating synchronized video and audio data of a requested video program;

an encoder means for receiving said video and audio data output by said decompression means and generating therefrom one or more signals carrying video and audio information of said selected program;

a microprocessor coupled at least to said transport stream demultiplexer and said tuner and programmed to control said set top decoder;

a buffer memory coupled to said transport stream demultiplexer and said microprocessor, and coupled to said decompression means;

conditional access means coupled to said transport stream demultiplexer, said buffer memory and said microprocessor, for carrying out a bidirectional conditional access protocol for requesting a session key for a requested program from a headend, decrypting a session key in EMM message data sent in response to said request, said EMM message data containing a session key for a requested encrypted video program, said decryption done using a private user key and for using the decrypted session key to decrypt ECM message data sent as part of said transport stream which carries said requested, encrypted video program to derive a working key and for using said working key to decrypt said requested encrypted video program;

a bulk storage medium for storing data;

a high data throughput bulk storage controller coupled to said microprocessor, said buffer memory and said bulk storage medium for controlling write and read operations of said bulk storage medium;

means for receiving user commands and transferring data to said microprocessor;

and wherein said microprocessor is programmed to control circuits in said set top decoder and said bulk storage medium through said bulk storage controller so as to cause said set top decoder to have personal video recorder capabilities.

33. The apparatus of claim 32 further comprising an analog-to-digital (A/D) converter coupled to analog video and audio data inputs of said STB, and an MPEG encoder having an input coupled to an output of said A/D converter and having an output coupled to said buffer memory.

34. The apparatus of claim 32 wherein said decompression means and said encoder means are removable as one or more modules and can be replaced individually or as a unit by one or more modules which contain decompression circuitry for different compression standards and encoder circuitry to encode output from said decompression circuitry into a selected one of a plurality of different television signal standard formats.

35. The apparatus of claim 32 wherein said conditional access means is removable and can be replaced by a substituted conditional access means.